

TECHNICAL NOTE

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SCIENTIFIC SATELLITES AND THE SPACE ENVIRONMENT

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1. The first part of the document is a list of the names of the people who were present at the meeting. The names are listed in alphabetical order.

2. The second part of the document is a list of the topics that were discussed during the meeting. The topics are listed in alphabetical order.

3. The third part of the document is a list of the actions that were taken during the meeting. The actions are listed in alphabetical order.

4. The fourth part of the document is a list of the dates when the actions were completed. The dates are listed in alphabetical order.

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by
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SUMMARY

This paper outlines the need for space science information in the next ten years and the general objectives of the NASA space programs. The scientific satellite is defined and contrasted to military and application satellites and a graphical summary of the satellites launched to date is presented. A typical space vehicle mission profile is also given. The general characteristics of the space environment, such as atmospheric structures, particles, and fields, are discussed. Major findings from satellites, such as the discovery of the Van Allen belts, the pear shape of the earth, and effects of solar radiation pressure, are briefly surveyed.

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In this act Congress declared "that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind."* The act established such general objectives as the advancement of space science and technology and their application to space flights for peaceful purposes, the enlistment of the cooperation of the scientific community, the promotion of international cooperation, and the fullest practicable dissemination of information on the space activities of the U.S. The act also provided that the Department of Defense should have the responsibility for military applications of space science and technology for national defense.

SPACE PROGRAM OBJECTIVES

The first objective (Reference 1) of the national space program is the scientific study of the space environment and celestial bodies to gain new scientific knowledge. The goals of these missions are: (1) to understand the nature of the connection between phenomena on the sun and events in the atmosphere and on the earth; (2) to understand the nature and origin of the earth, the solar system, and the universe; and (3) to search for the presence of life outside the earth. Such knowledge is needed also in the design of spacecraft adequate for the exploration of the solar system both by instruments and by man himself.

The second major scientific national objective of the U.S. program is the early application of earth satellites to practical uses for human benefit. Current applications are to weather research and forecasting, global telephone and television communications, and navigation.

The third specific national objective is to study the role of man in space and to begin the manned exploration of space. The suborbital flights by Commander Alan Shepard and Captain Virgil Grissom on May 5 and July 21, 1961, respectively, were the first steps in this program.†

Scientific Satellites

The scientific satellite is a man-made object placed in a selected orbit to make scientific observations of the space environment and relay this information to earth. In addition to the scientific satellite, there are application, manned, and military satellites. Figure 1 indicates all the satellites which have been launched through September 13, 1961 (Reference 2). It will be noted that the U.S. has launched over three times as many satellites as the USSR, but has placed only about half as much weight in orbit: 60,000

*Public Law 85-568, 72 Stat. 426, July 29, 1958, 42 U.S. Code 2451.

†As this report goes to press Lt. Col. John Glenn has just made his historic orbital flight of February 20, 1962.

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INTRODUCTION

On May 25, 1961, President Kennedy said in a message to the U. S. Congress:

"Now it is time to take longer strides—time for a great new American enterprise—time for this Nation to take a clearly leading role in space achievement. . . . I believe that this Nation should commit itself to achieving the goal, before the decade is out, of landing a man on the moon and returning him safely to earth."[†]

With this statement the President launched a very bold and vigorous program for this decade. Congress has enacted the necessary legislation to implement this program. The travel of man to the moon and his safe return to earth is a goal which will accelerate the development of a massive capability in space science and technology. The benefits of such a program can be applied to other space missions, and will enhance our general position as a leader in the application of science and technology for practical benefits to mankind.

This paper discusses scientific satellites and their contribution to space science and to understanding of the space environment. It is intended to serve as primer on both the space environment and the scientific satellite. It is hoped that this elementary presentation will help to bridge the gap between the diverse backgrounds represented in technology, and thereby contribute to a better understanding of the vast and complex problems facing the scientific community.

THE NASA MISSION

The National Aeronautics and Space Administration is charged with the responsibility for scientific satellites through the National Aeronautics and Space Act of 1958.

*This report was presented as paper J-1 at the Thirtieth Shock and Vibration Symposium, October 12, 1961, Detroit, Michigan.

†"Urgent National Needs" Address of the President of the U.S. before a joint session of Congress, 87th Congress, 1st Session, H.R. 174, p. 11.

Application Satellites

U.S. application satellites have been particularly successful. The TIROS (from Television and Infra-Red Observation Satellite) program is a notable example (Reference 5). It has had three highly successful launches, April 1, 1960, November 23, 1960, and July 12, 1961.* These 250 to 300 pound satellites carry television cameras and infrared instrumentation in orbits having an average distance from the earth of about 450 miles. TIROS I (1960 β_2) transmitted nearly 23,000 television pictures of the earth's cloud cover (Figure 2); TIROS II (1960 π_1) has relayed important information about the earth's atmosphere and the radiation of solar heat back from the earth into space; TIROS III (1961 ρ_1), orbited to coincide with the hurricane season, is providing excellent pictures on tropical storm development and movement. The head of the U.S. Weather Bureau (Reference 1) assesses the meteorological satellite, of which TIROS is an early research prototype, as the most significant development in the history of meteorology, of greater importance than the invention of the barometer. Echo I (1960 ϵ_1) is an example of an application satellite in the communication field which has been seen by millions of people around the world. This 100-foot aluminum-coated plastic sphere, in orbit for over 14 months, has demonstrated the feasibility of a passive communication satellite and confirmed radio wave propagation theory. Some of the most significant findings from Echo I are enumerated in Table 1.

Forthcoming communication satellites, both "passive" (REBOUND) and "active", (RELAY), will greatly enhance the march toward world-wide "triple T" communication (telephone, telegraph, and television).

Table 1

Major Findings from the Echo I Communication Satellite

Communication Studies

- Relay of message from President Eisenhower during first orbit.
- Transmission of RF energy between U.S. and France.
- Voice and music communication between U.S. and England.
- Telephone conversation between east and west coasts of U.S.
- Facsimile photographs and letter transmitted by U.S. Post Office Department.

Scientific Studies

- Confirmed orbital behavior theory with respect to solar radiation pressure.
- Revealed that atmospheric drag increases with solar flares or storms.
- Revealed that large, inflatable structures will survive long periods in space.

*As this report goes to press Tiros IV (1962 β_1) has been launched successfully into orbit, February 8, 1962.

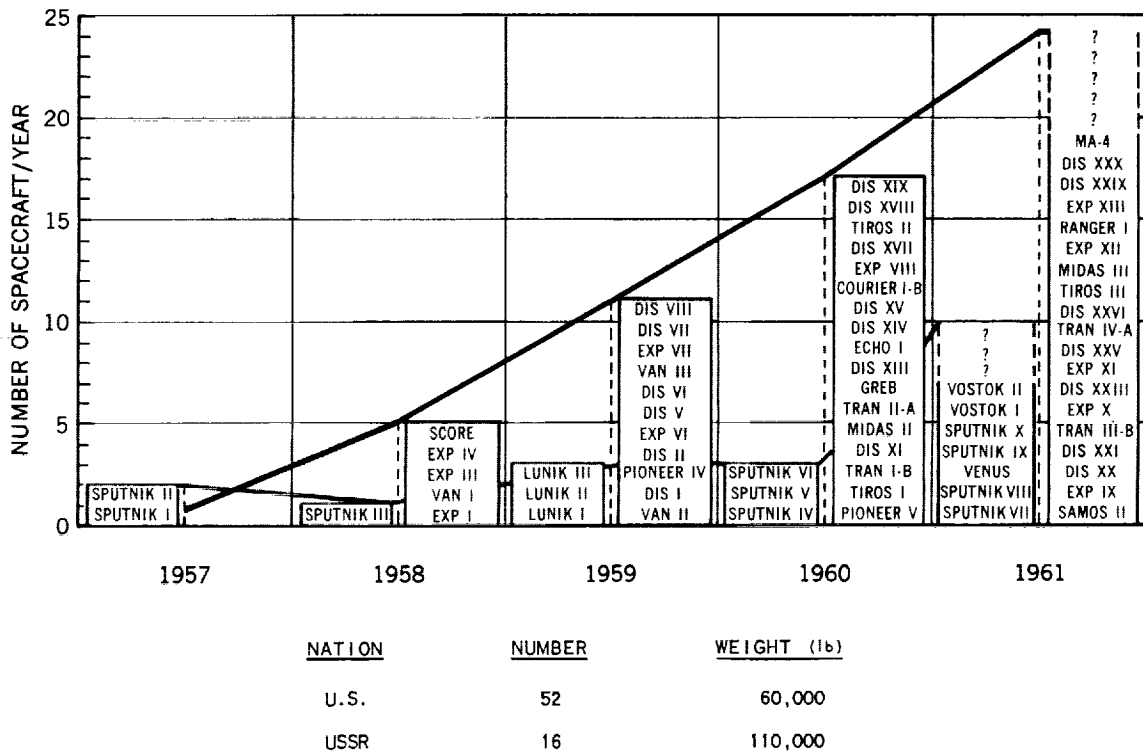


Figure 1—Spacecraft orbited as of September 13, 1961

pounds compared to 110,000 pounds. The cost of the U. S. space effort through fiscal year 1961 totaled nearly \$4,000,000,000 (Reference 3). Therefore each successful U. S. launch has cost about \$80,000,000 and the average cost per pound of material in orbit has been about \$67,000. U.S. launch attempts have been successful slightly better than 50 percent of the time (Reference 4). It has been estimated that in less than ten years the U.S. annual orbit capacity (for an average orbital altitude of 300 nautical miles) will exceed, by a factor of ten, the 60,000 pounds now in orbit. By that time a single spacecraft may weigh as much as the U.S. poundage now in orbit.

The U.S. scientific satellites to date have enabled man to make some very striking discoveries. For example, Vanguard I (1958 β_2) exhibited unexpected orbital effects from which the pear-like shape of the earth was deduced, and the Explorer series disclosed the existence and measured the extent of the great Van Allen radiation belts. Pioneer V (1960 α), a deep space probe, provided much information on the nature and spatial relationships of interplanetary storms and particles. This latter satellite established a distance record for radio communication, 22.5 million miles.

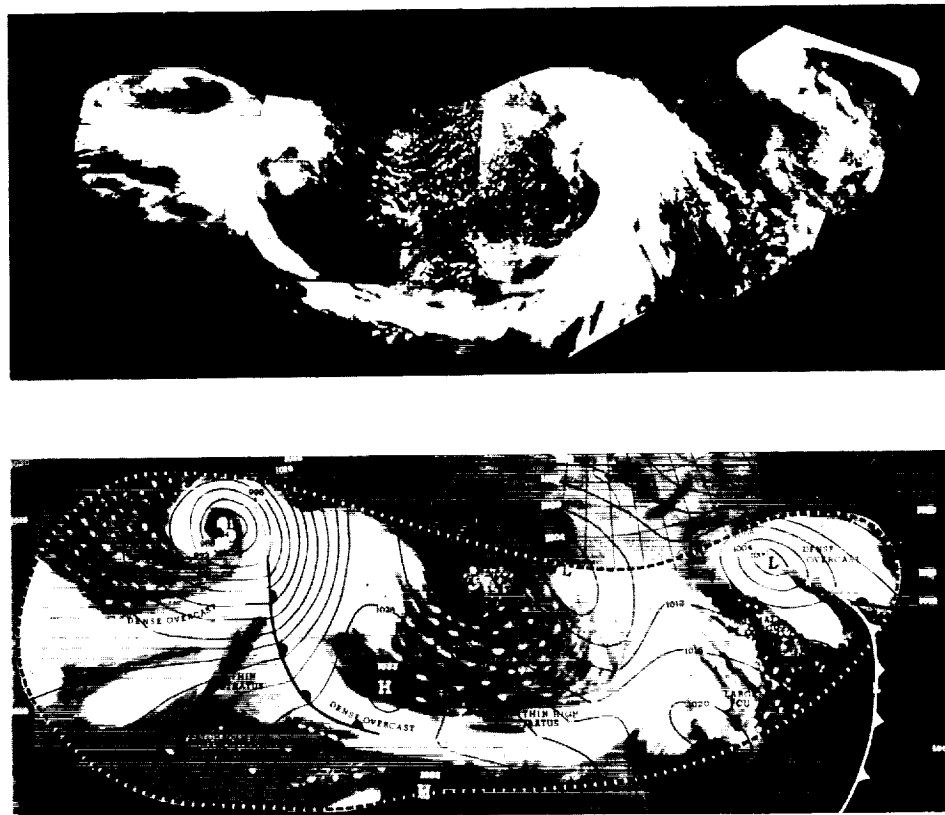


Figure 2—Photographic mosaic of an extensive weather system (top) taken by TIROS I, and corresponding weather map (May 20, 1960)

The application of satellite techniques to the communication field is being investigated jointly by the government and private industry. Dr. L. V. Berkner, chairman of the Space Sciences Board, National Academy of Sciences, has indicated that satellites can increase the world communication capacity by a factor of 10,000 (Reference 6).

Military and Manned Satellites

A second contrast to the scientific satellite is the military satellite, which is devoted to fulfillment of some mission in the national defense. Examples of such satellites are those in the Advent, Saint, Transit, and Midas programs. The Air Force's Discoverer program is probably the best known. This is a scientific research program aimed at establishing military spacecraft technology through a series of short-life, low altitude satellites. The program has continued since February 1959 at the rate of about one launch per month.

The U.S. manned satellite program has its beginning in Project Mercury. This project has had extensive review and publicity and will not be discussed here. The follow-up program to Mercury will be the Apollo project which is intended to provide a Manned Orbiting Laboratory and manned circumlunar flight. The Apollo vehicle is currently conceived as a three-man spacecraft.

Sounding Rockets

The most important tool in space science research to date has been the sounding rocket (Reference 7). This vehicle probes the near-earth atmosphere (major efforts have been in the 20-200 mile region but multiple stage rockets can achieve altitudes to 4000 miles) by placing a 25 to 150 pound scientific experiment in space for a few minutes in a nearly vertical flight profile. The great value of sounding rockets lies in their cheapness, simplicity, and reliability; however their measurements are limited to specific regions and times. The scientific satellite is a natural extension of the vertical sounding rocket for space sciences investigation. The differences in trajectories of sounding rockets, satellites, and space probes are shown in Figure 3.

Launch Vehicles

In order to orbit, the scientific satellite must be launched by a vehicle which can lift it to the desired altitude and provide it with sufficient kinetic energy to achieve orbital velocity. Typical existing and proposed vehicles are shown in Figure 4, where they are compared on a common basis by their payload capacity for a 300 nautical mile orbit.

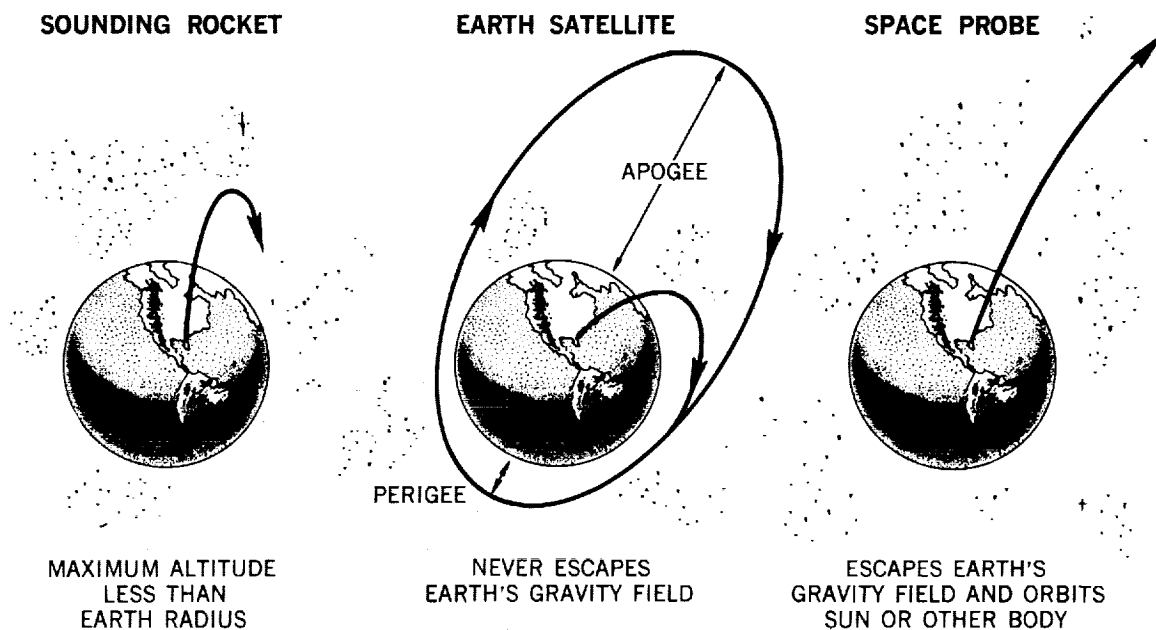


Figure 3—Space exploration

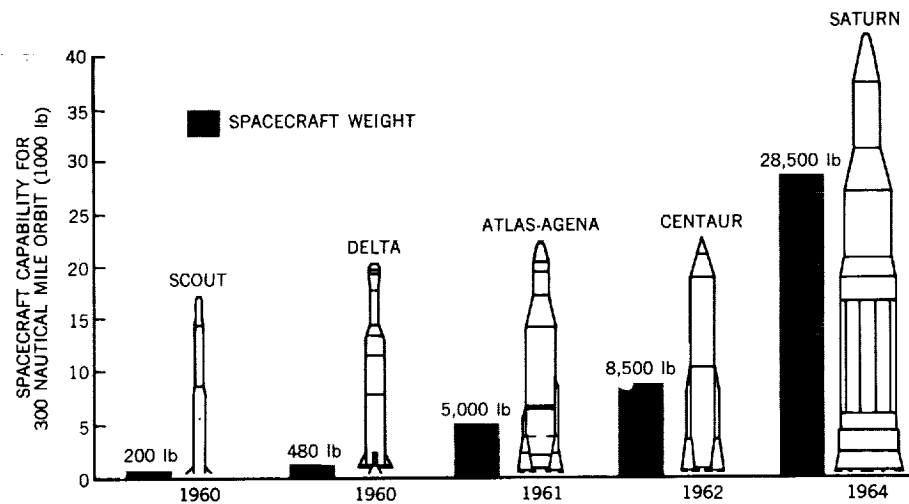


Figure 4—Existing and proposed launch vehicles for scientific satellites

In a typical space vehicle there is a multistage rocket booster with varying degrees of guidance and control which lifts the spacecraft or payload to the proper altitude. When the satellite leaves the earth's atmosphere, the spacecraft fairing is jettisoned (Figure 5). A final rocket stage provides the required impulse to accelerate the payload to the required orbital velocity (Figure 6). After orbital velocity is achieved, the satellite is given a small velocity increment relative to the last rocket stage by a mechanical spring which provides final separation (Figure 7).

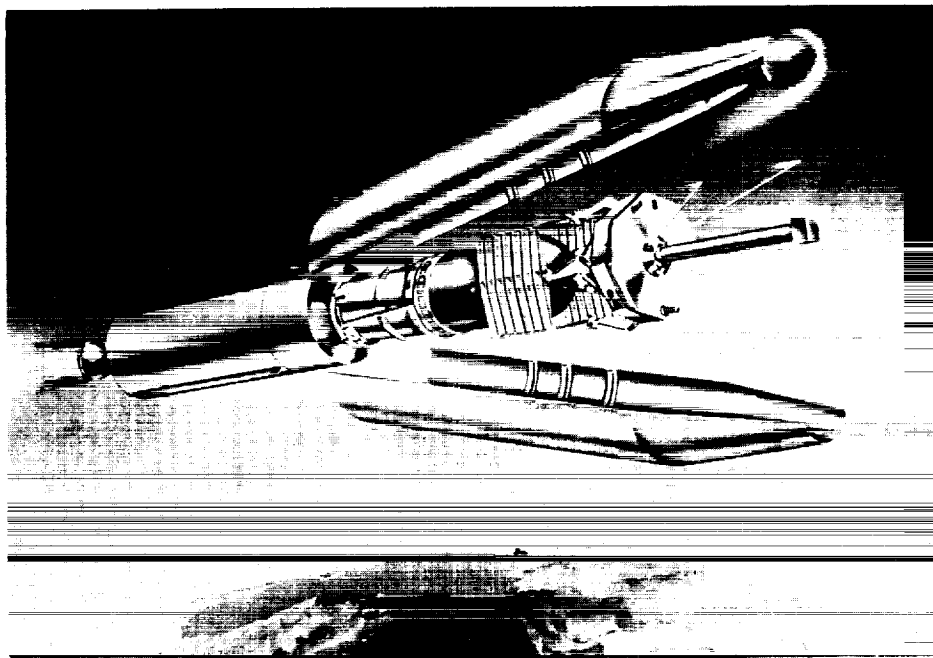


Figure 5—Jettisoning of the nose fairing

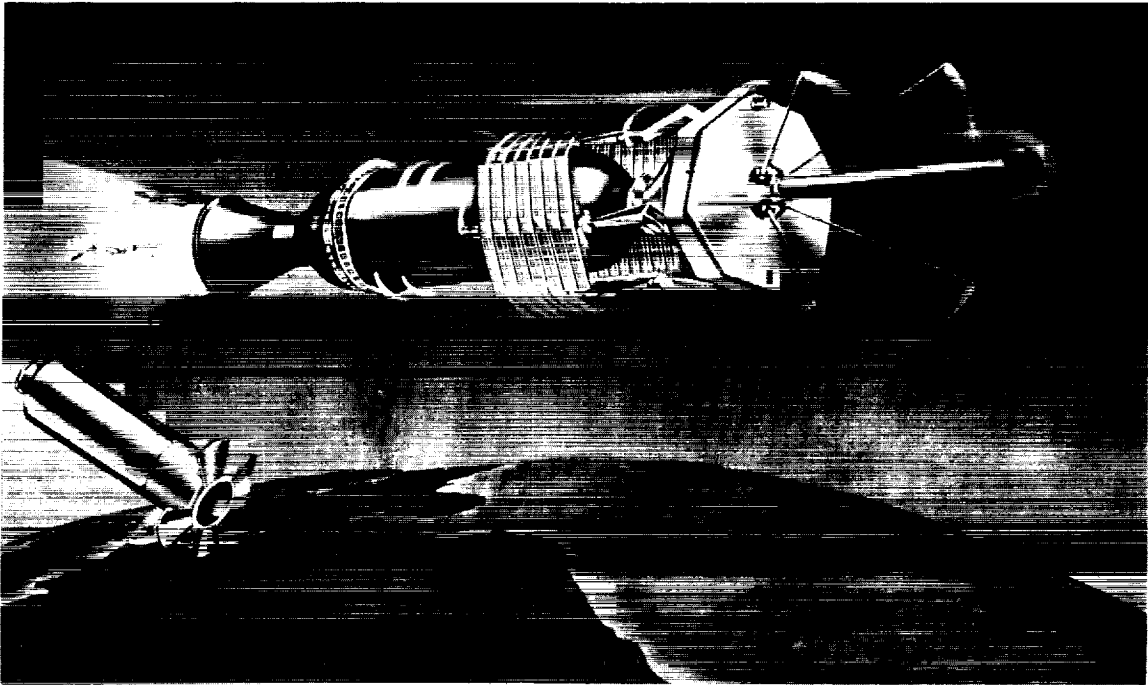


Figure 6—Orbit injection

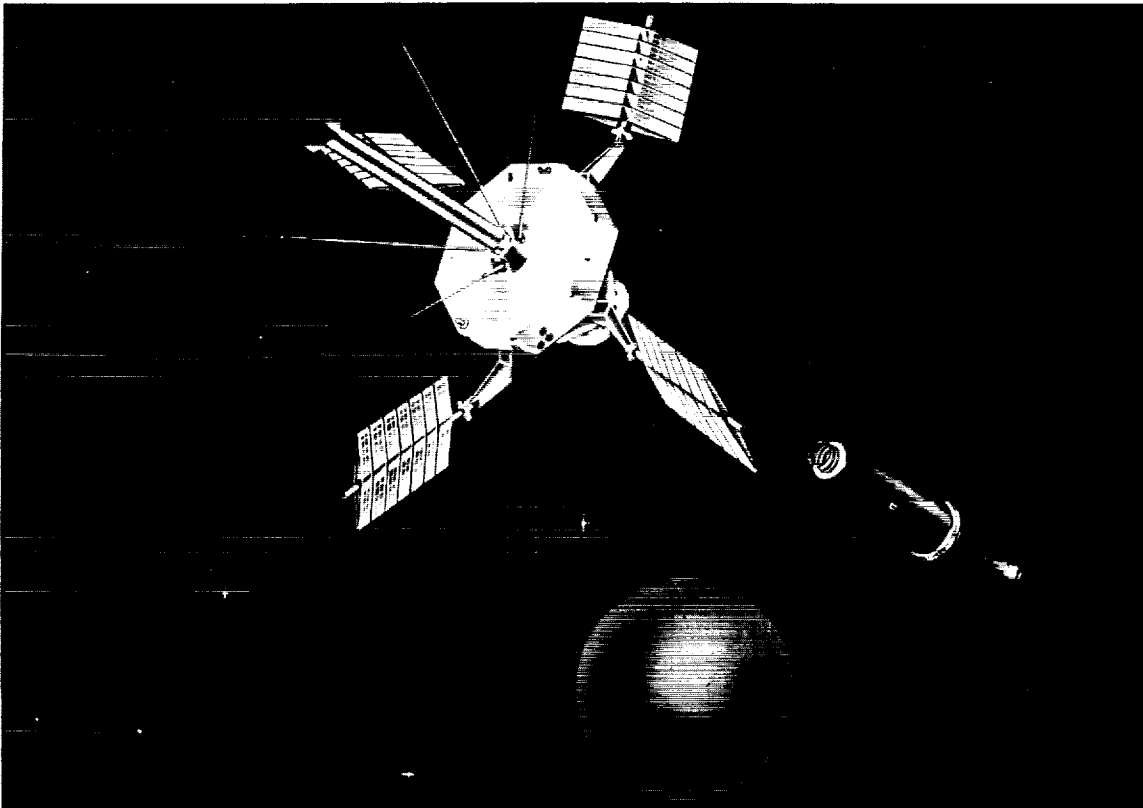


Figure 7—Final satellite separation

SATELLITE STRUCTURE AND MISSION

Present-generation scientific satellites may vary in weight from less than 100 pounds to more than 1000 pounds. A typical weight distribution among the primary elements of a satellite might be: structure - 25 percent; scientific experiment - 20 percent; communication electronics - 30 percent; power supply - 25 percent (batteries-50 percent, solar cells-50 percent). These primary elements are shown in Figure 8 for the Explorer XII (1961_v) Energetic Particles Satellite.

As previously stated the purpose of a scientific satellite is to collect data about the space environment. Present-generation scientific satellites are designed for specific purposes. For example, Explorer XII measures energetic particles and magnetic fields. As can be seen in Figure 9, its highly elliptical orbit (nearly 50,000 miles at apogee vs. about 500 at perigee) allows it to investigate the inner and outer Van Allen belts, the variation of the earth's magnetic field, interplanetary magnetic fields, cosmic rays, and charged particles other than those included in these components of space. This particular satellite is carrying ten different particle detection instruments.

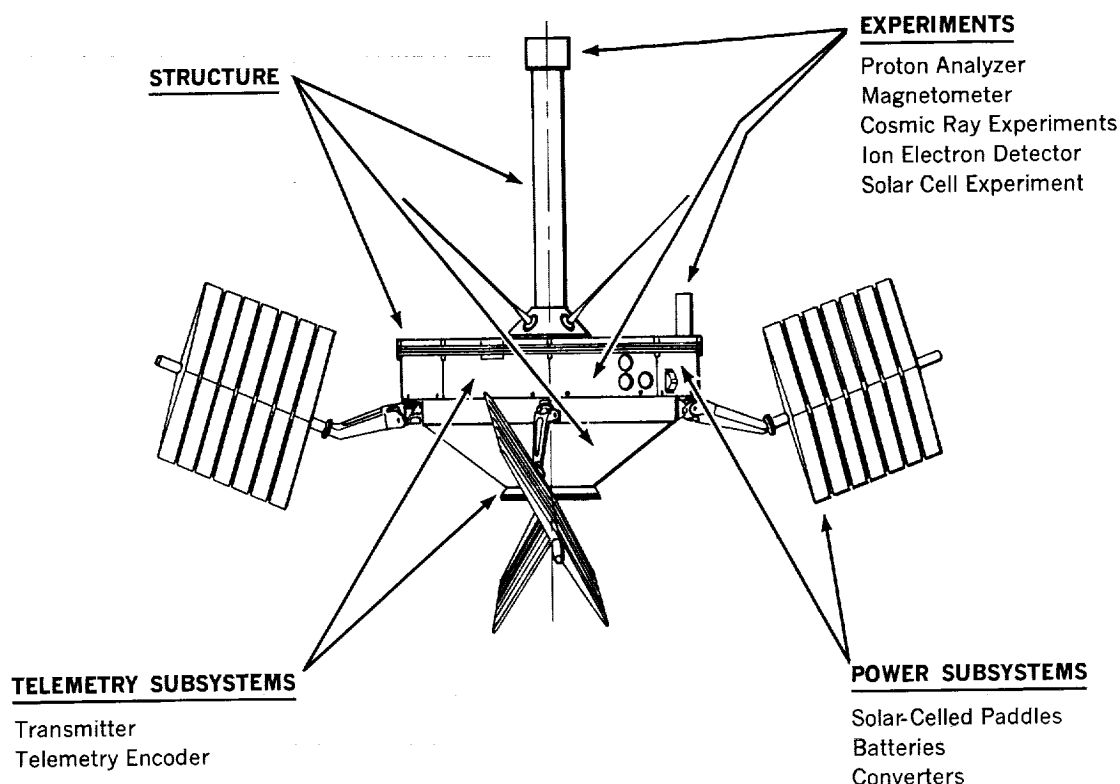


Figure 8—Principal elements of the scientific satellite Explorer XII

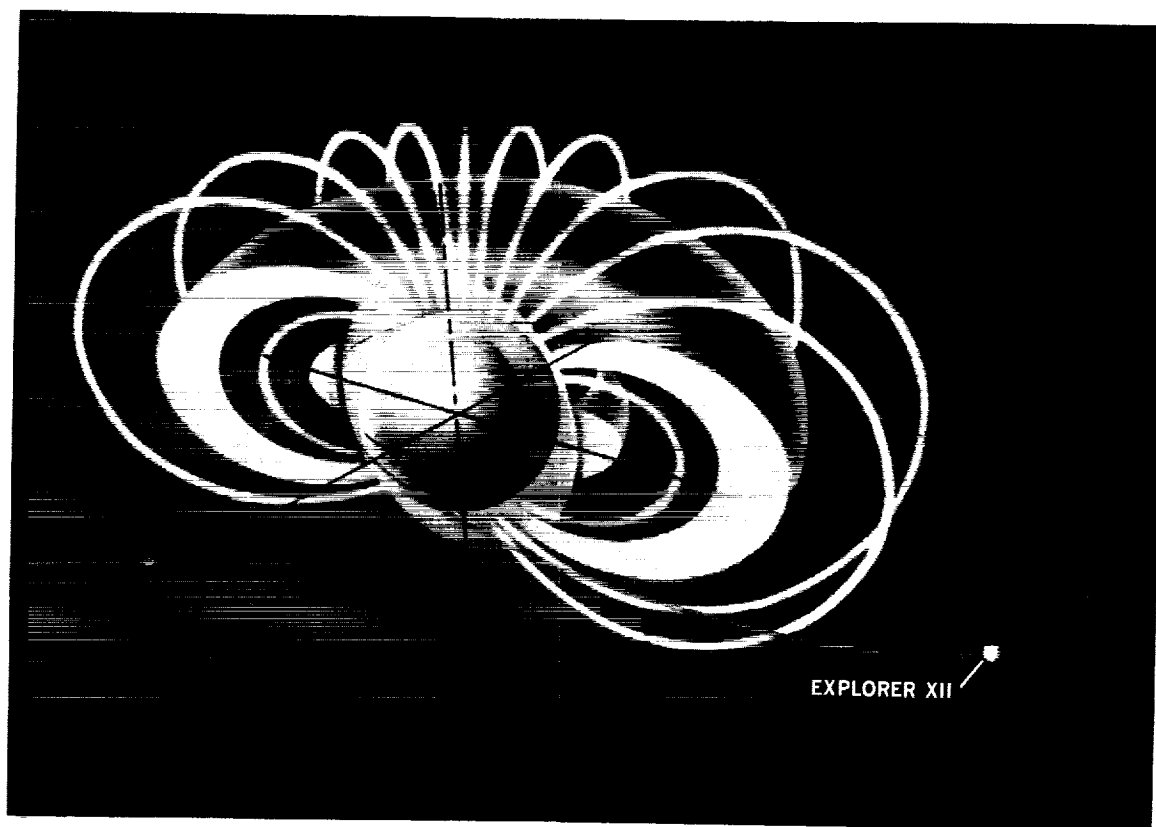


Figure 9—Highly elliptical orbit of Explorer XII traversing both inner and outer Van Allen radiation belts

FUTURE SATELLITES

Future scientific satellites are generally called observatories. They will include a multitude of scientific experiments provided through international cooperation, as well as experiments representing the best in American technology from universities and industrial and Federal establishments.

The orbiting Geophysical Observatory (OGO) can accommodate up to 50 space experiments (Figure 10). This Earth-Oriented half-ton spacecraft measures about 3 feet in width and depth and 6 feet in length. It has several booms, the longest of which locates experiments 21 feet from the spacecraft proper. OGO represents a standardization in design resulting from the development of modular concepts. Experimenters can get their equipment on board at the last minute and occupy a standardized module; that is, the experiment need be planned only several months ahead rather than 2 to 3 years as is now required. Also, these satellites will be launched at regular intervals - one or two a year - so if a given experiment "misses" one satellite it can shortly be placed on board another.

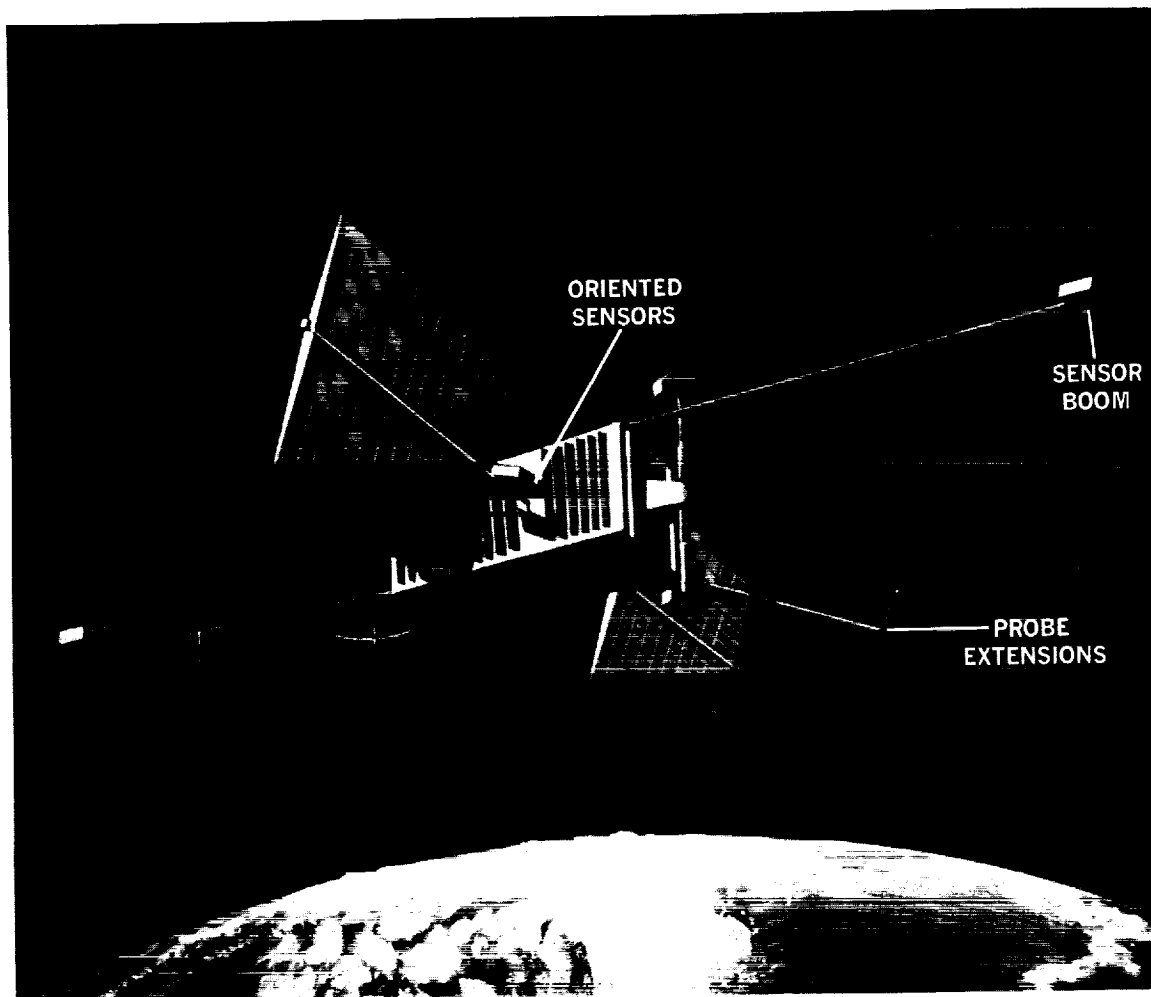


Figure 10—Orbiting Geophysical Observatory *

The Orbiting Solar Observatory (OSO), a 440 pound satellite, is designed to look always at the sun (Figure 11). The top portion (solar cells and telescopes) rotates on a center bearing. The lower wheel structure (with about a 44-inch diameter) will spin to provide stability. Gas stored in the balls on the arms acts through jets to orient the satellite. The OSO will permit the study of the surface of the sun and the corona around the sun, and spectroscopic measurements and examination of sunspots in detail. It will provide man his first opportunity to accurately point his instruments at the sun outside the limiting "window" of the earth's atmosphere.

The Orbiting Astronomical Observatory (OAO) is the heaviest unmanned satellite currently planned (Figure 12). It will weigh about 3500 pounds and will carry a large telescope (36 inch diameter). This satellite has some very stringent requirements for pointing accuracy - about 0.0003 degree or about 1 second of arc. This opportunity to get

*The configuration of this spacecraft has changed slightly since this figure was drawn.

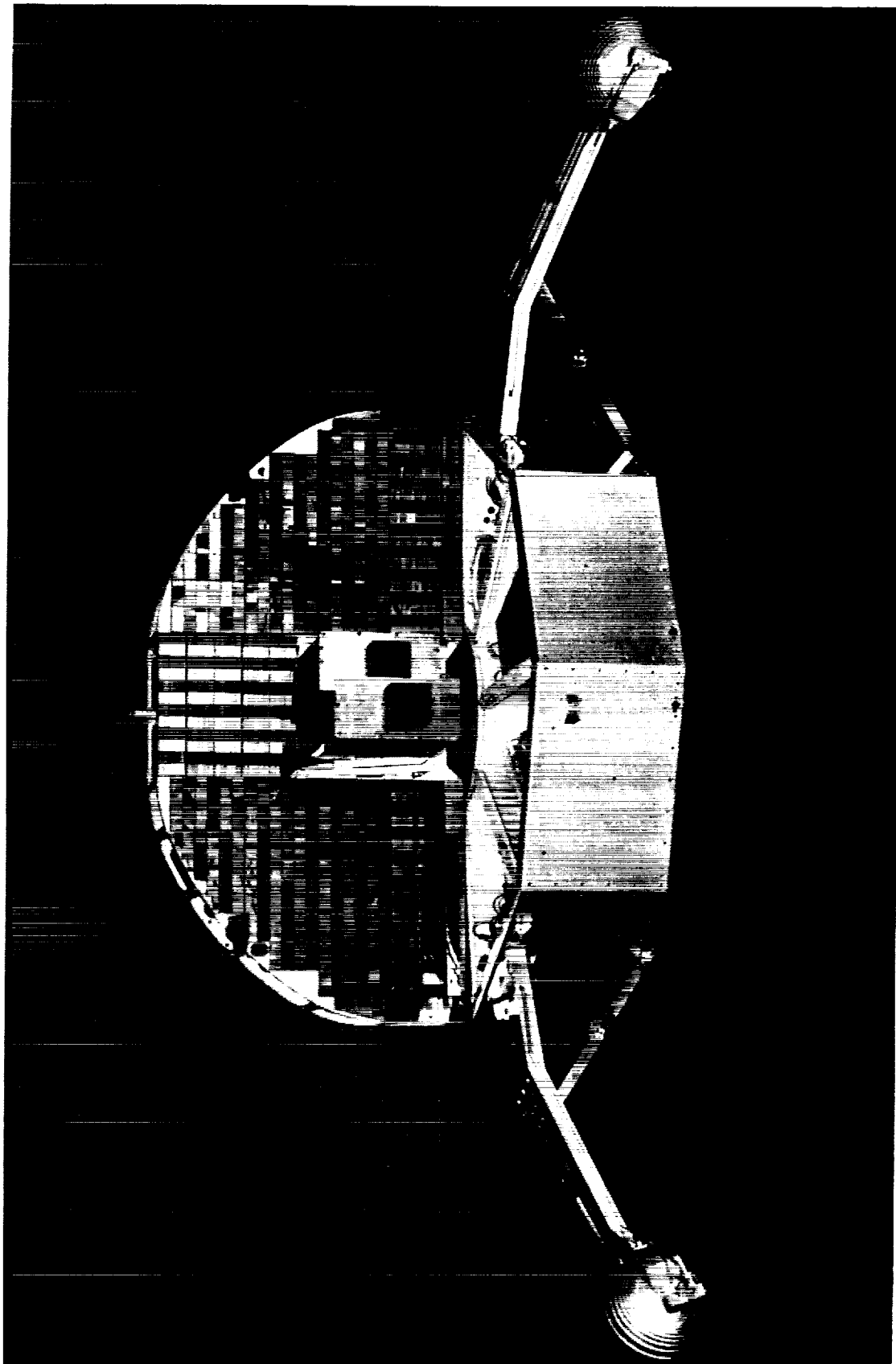


Figure 11—Orbiting Solar Observatory

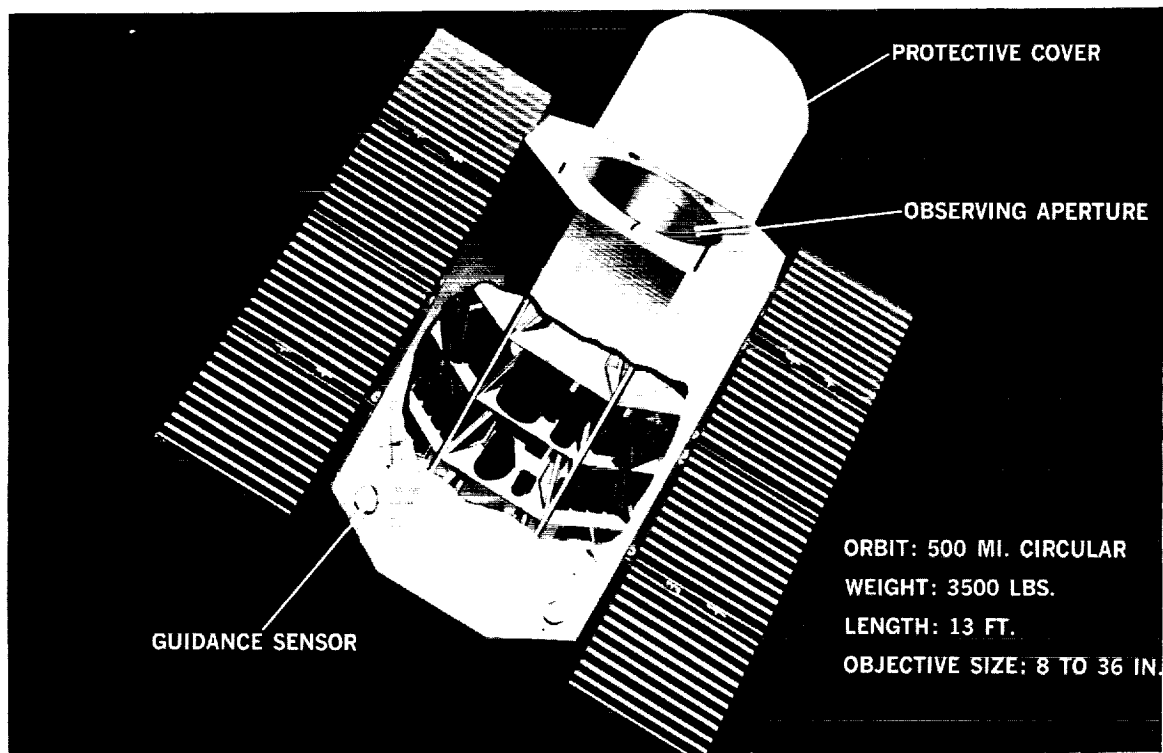


Figure 12—Orbiting Astronomical Observatory

a telescope beyond the limiting effects of the earth's atmosphere has been the dream of every astronomer.

THE SPACE ENVIRONMENT

In some areas experimental data about the nature of the space environment are plentiful; information in other subject areas is based almost entirely on theoretical concepts. For convenience we will consider the space environment to include only the earth's atmosphere, interplanetary space, and their components. Space is characterized by fields and particles which are substantially different from those on earth. These include magnetic fields, the Van Allen belts, cosmic rays, micrometeorites, and solar and other thermal radiation.

Atmospheric Structure

It is appropriate to review the structure of the earth's atmosphere first (Figure 13, Reference 8). The composition of this cloud of gas, 99 percent of which lies below 20 miles, is roughly, by volume, 78 percent N_2 , 20 percent O_2 , about 1 percent water vapor (varies from 0.3 to 2 percent), less than 1 percent argon, together with some CO_2 and ozone (O_3). These gas molecules decrease in amount as the distance from the earth

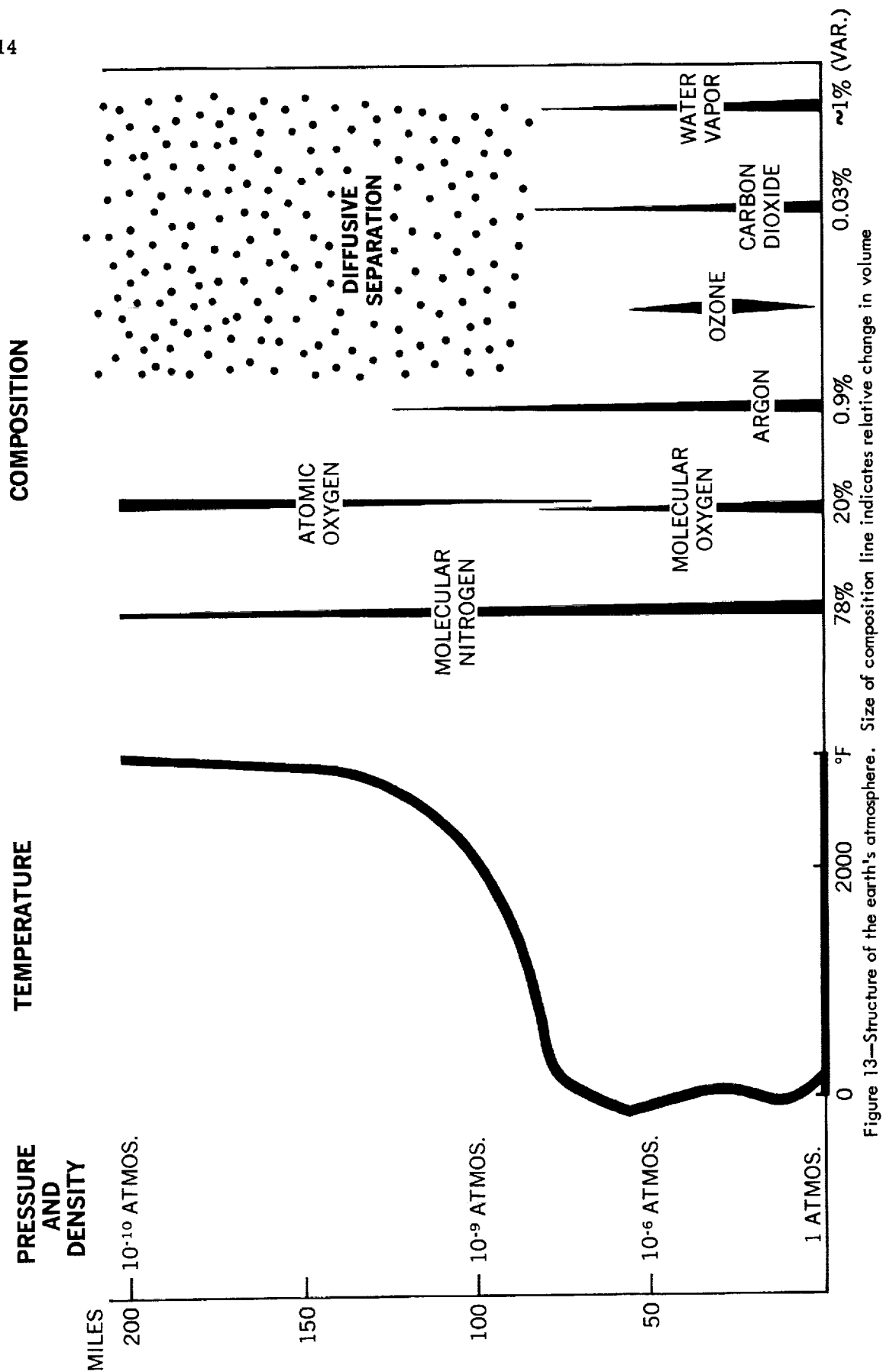


Figure 13—Structure of the earth's atmosphere. Size of composition line indicates relative change in volume

increases except ozone, which reaches a maximum at 20-30 miles due to the ultraviolet action of the sun's rays. Above about 60 miles, the molecular oxygen begins to dissociate into atomic oxygen due to the effects of the sun's radiation. At an altitude of about 100 miles diffusive separation takes place - the light gases go up, the heavier gases go down. As can be noted from the pressure scale (Figure 13) at 100 miles the pressure is 10^{-6} mm Hg and decreases by a factor of 10 for the next 100 miles. Pressure decreases roughly by a factor of 10 for every 10 mile increase in altitude up to about 100 miles (Reference 9).

The temperature curve shown in Figure 13 is based on the average kinetic energy of the gas molecules. In the denser, lower atmosphere, this represents the sensible temperature, that is, what a thermometer would read. In the upper atmosphere, where there are few gas molecules, it means they are moving rapidly. They have lots of kinetic energy per particle but there are very few of them. As a consequence a satellite is heated very little by these atmospheric gases.

The earth's ionosphere is the spherical shell of charged atmospheric gases which stretches from 40 miles to tens of thousands of miles above the earth (Reference 8). Because the gas molecules are exposed to intense radiation from the sun, electrons are separated from the molecules giving free electrons which together with the remaining molecules, now called ions, are the charged particles that produce ionospheric effects. Maximum electron densities per cubic centimeter are on the order of 2×10^6 . The ionosphere is important in world-wide communications. However, it is quite variable, being affected by solar activity, geographic latitude, and altitude, as well as having daily and seasonal changes (Figure 14). The daytime ionosphere is characterized by the D, E, F1, and F2 regions at approximate altitudes of 35, 60, 120, and 180 miles, respectively. At nighttime, the atmosphere becomes more quiescent and the D region disappears, the E region becomes sporadic, and the two F regions merge into a single region. These regions might be thought of as electronic sieves which selectively pass or reject radio frequency transmission. Thus commercial broadcasts are reflected by the E layer, shortwave by the F layer, and TV and higher frequencies pass through the ionosphere.

The principal effects that the ionosphere has on a satellite is the creation of a space charge around the object, the effect on radio communications to and from the satellite, and the increased drag which the charge may create. Explorer VIII (1960 ϵ_1) data have shown that the electrical "size" of a satellite may double because of the cloud of ionized particles surrounding it.

Magnetic Fields

Out to about 5 earth radii the magnetic field about the earth agrees very well with that calculated for a theoretical dipole. At the earth's surface the total magnetic intensity is about 0.5 gauss or 50,000 gamma. In the range of 8 to 12 earth radii, deviations in the

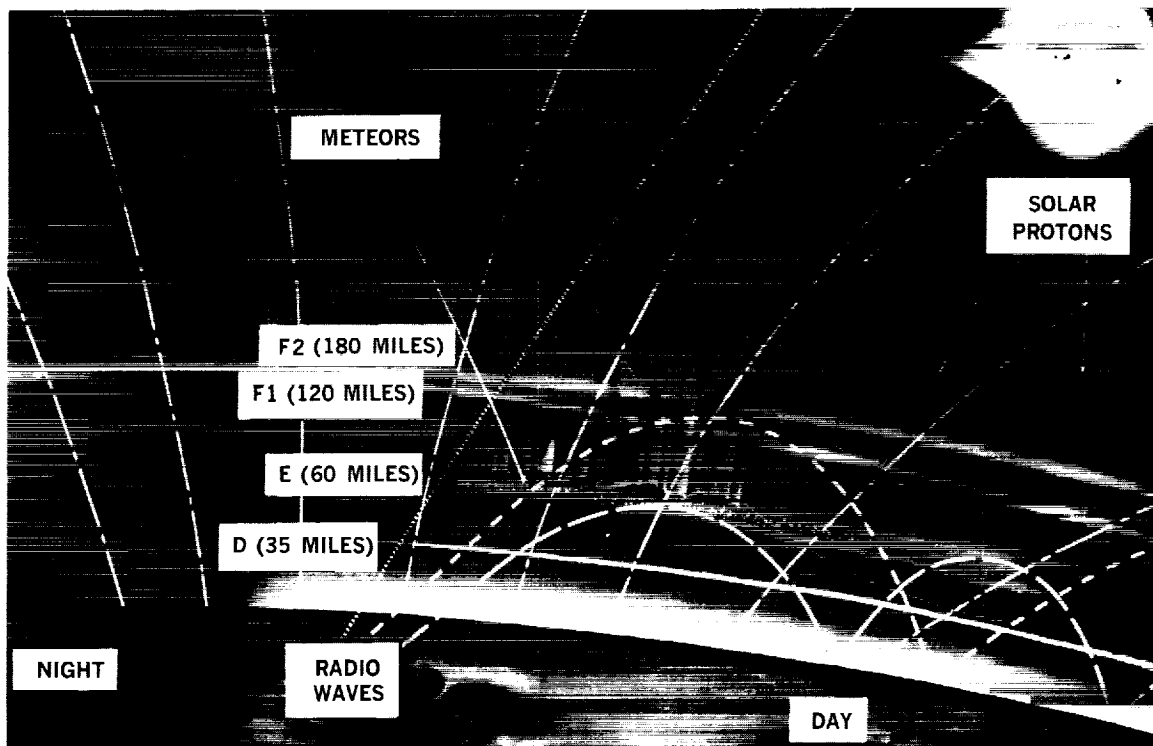


Figure 14— The ionosphere

magnetic field suggest the presence of a strong ring current of several million amperes (Reference 10); beyond about 15 earth radii the magnetic field becomes quiescent, having an interplanetary value of about 2 to 4 gamma. Accurate knowledge of the magnetic fields of space may provide the basis for making so-called "road maps" of space. Also, as knowledge increases and becomes more accurate, it may be possible to exploit this phenomenon to control a spacecraft's attitude or to sense its motion or velocity.

Radiation Belts

One of the primary effects of the earth's magnetic field is trapping energetic particles and concentrating them into what are known as the Van Allen radiation belts. These two belts generally are depicted as in Figure 15. The particles in these belts carry energies of about 20,000 to several million or more electron volts. The maximum distance of the outer zone lies between 3 and 4 earth radii. It is thought to be made up primarily of electrons. The inner zone is at about 1-1/2 earth radii, is better defined, and is thought to be made up primarily of protons. The outer belt flux varies markedly with solar flare activity. It is now suspected that the particles in these belts cause the earth's aurora.

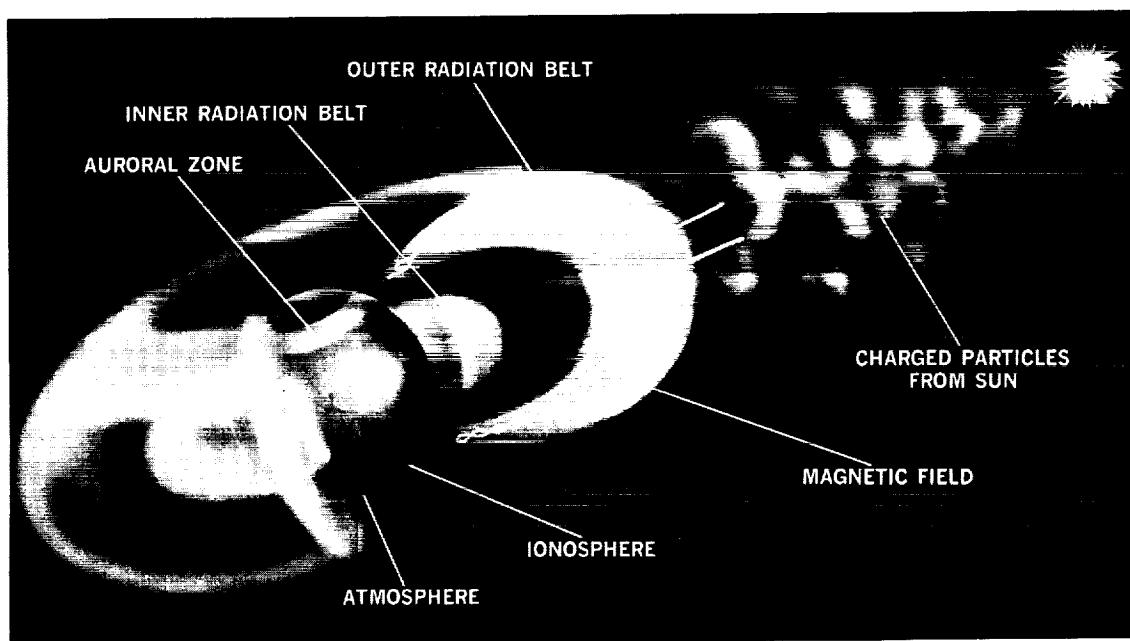


Figure 15—Radiation belts

Dr. Robert Jastrow, Goddard Space Flight Center, stated:

"The entire matter of Sun-Earth relations, including the information of the Van Allen Belts and their possible role in geophysical phenomena, constitutes a relatively new area of research in each of the sciences. It is an area which was greatly stimulated by the discovery of the Van Allen Belts during the IGY, which is at the moment perhaps the most exciting and fruitful field of research in the space science program."^{*}

Cosmic Rays

Cosmic rays pervade all of outer space (Reference 8). These particles individually may have very high energies (as much as 10^{15} ev). Fortunately, the intensity of these particles is very low and the total energy they bring to earth is about equivalent to that of starlight (Figure 16). The particles are deflected by magnetic fields (Figure 15). Satellite observations have shown that the so-called Forbush decrease, the drop in intensity of cosmic rays on earth during a magnetic storm, can be ascribed to "magnetized plasma clouds" which move out across interplanetary space at a speed of about 1000 miles per second. In space there are probably less than 0.5 particles/cm² per second for all directions. The particles themselves are nuclei of atoms. About 90 percent of the cosmic rays are protons. Most of the remaining 10 percent are alpha particles, although 1 or 2 percent of heavier atoms (up to about iron) have been detected (Figure 16).

^{*}NASA Scientific and Technical Programs, Hearings before the Committee on Aeronautical and Space Sciences, U.S. Senate, 87th Congress, 1st session, February 28 and March 1, 1961, Washington, U.S. Govt. Print. Off., 1961, p. 125.

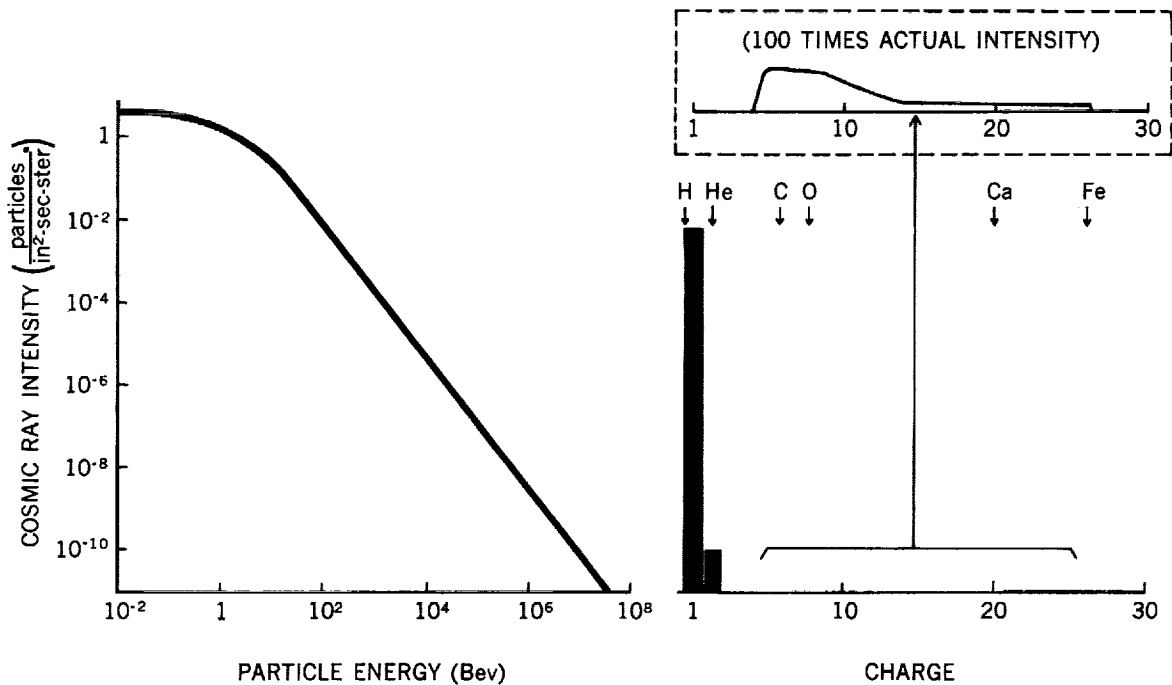


Figure 16—Cosmic ray energy and charge spectrum (Reference 8, page 598)

Micrometeorites

The "particles" in space range in size from the submicroscopic to something as large as the sun or larger. The larger ones are easily detected and observed either visually, optically, or by radio waves. The smaller particles (less than 1 mm) are very difficult to measure. This interplanetary dust is very frangible and porous. While its existence in interplanetary space is well established, the sizes, masses, spatial distribution, and velocities of the particles are not well known. The problem of measurement involves the correlation of these parameters with impacts (on spacecraft) and the adequate calibration of sensors. The size does range down to a few microns, and mass densities of 0.05 to 1 gm/cm³ have been assumed. Velocities near the earth can vary from a lower limit of around 10 km/sec (determined by the earth's gravitational field) up to about 70 km/sec, the maximum velocity for particles at the earth's distance from the sun. An average velocity of about 30 km/sec is often assumed for micrometeorites. There are wide variations in the measurements to date. The figure of 10⁻⁷ impacts/cm² per second for masses larger than 3 x 10⁻⁹ gm can give a "feel" for the nature of the problem. But daily counts may vary by a factor of five. The daily influx rate of interplanetary dust has been estimated to be from 1000 to 10,000 tons per day on the earth (Reference 11).

Thermal Radiation

Solar radiation has been extensively studied and its total intensity is known within a few percent (Reference 12). There are three primary parts to the solar spectrum (Figure 17). The ultraviolet, with wavelengths from 0.2 to 0.4μ , accounts for about 9 percent of the total energy. This region of the spectrum is subject to the most speculation since it is effectively shielded from direct ground observation by the earth's atmosphere. Satellites are providing the first good measurements in this region. The visible spectrum (0.4 to 0.7μ) takes in about 40 percent of the energy and the infrared region (0.7 to 7.0μ) about 51 percent. (The actual energy between 0.7 and 2.0μ , as shown by the graph, is 45 percent.) The peak energy is associated with a wavelength of 0.45μ . The amount of energy in the spectrum below 0.2μ is less than 0.02 percent and similarly the amount of energy above 7.0μ is less than 0.04 percent.

The electromagnetic radiations encountered by a satellite beyond the earth's atmosphere are shown by Figure 18. The direct radiation from the sun, the solar constant, is the value of the total area under the curve in Figure 17 and has a value of 0.14 w/cm^2 or 130 w/ft^2 . The earth's albedo is that portion of the incident radiation which is reflected back into space without being absorbed by the atmosphere.

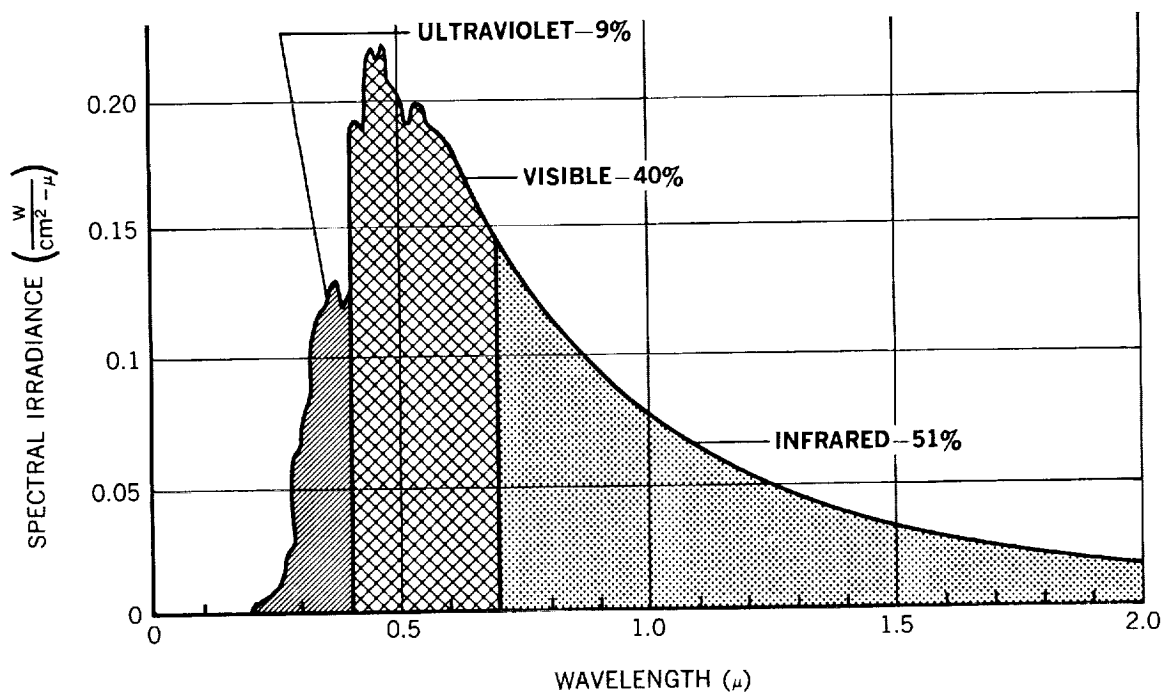


Figure 17—Solar spectral irradiance above the earth's atmosphere at the earth's mean distance from the sun

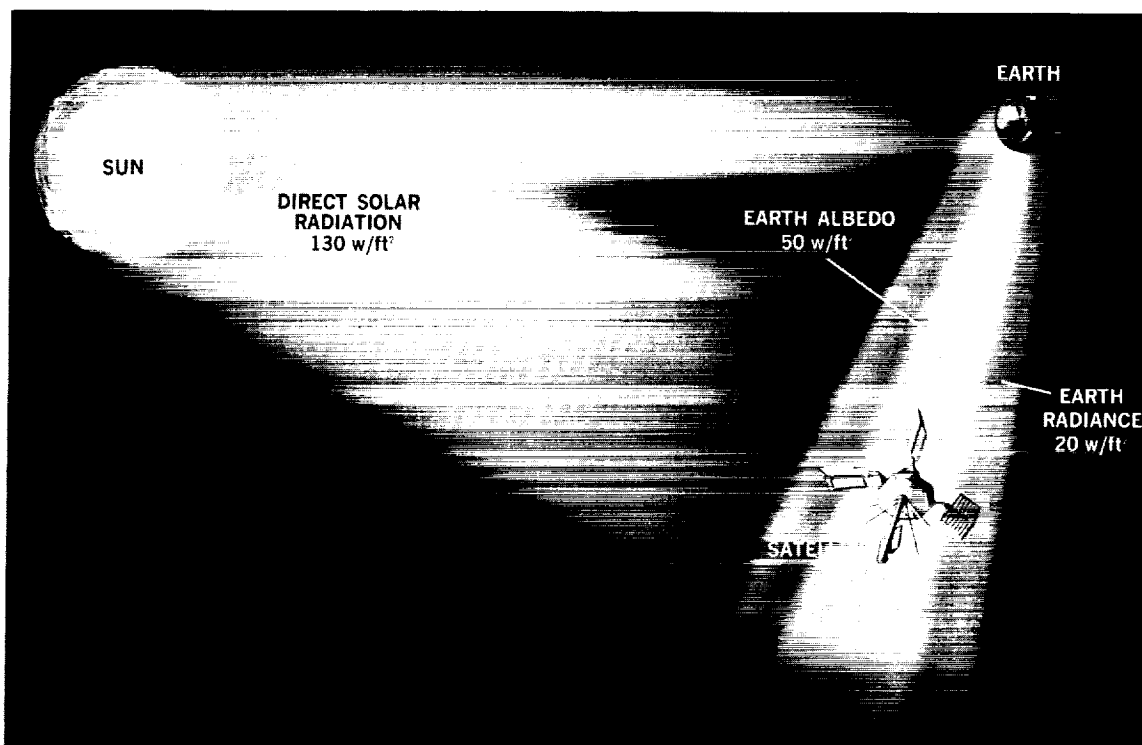


Figure 18—Thermal Radiations encountered by an earth satellite

It varies from 30 to 40 percent of the solar constant and depends upon latitude, season, and atmospheric conditions. A typical value for the earth's albedo is 50 w/ft^2 . The earth and its atmosphere also emit radiation characteristic of the infrared region. The total energy is typically around 20 w/ft^2 . It should be noted that a satellite's temperature is determined by the radiative heat balance between the aforementioned thermal flux, its on-board heat sources, its thermal capacity, and the absorptivity and emissivity properties (a/e ratio) of the satellite surface. Satellite equilibrium temperatures between 0° and 60°C are not difficult to achieve.

Although solar radiation has been primarily considered from the viewpoint of its thermal effects, it also creates a definite force which affects satellites. For large-area low-mass objects, this radiation pressure can affect orbits appreciably. The perigee for Echo I, for example, has been decreased by more than 30 percent by radiation pressure (Reference 13). There is evidence that the increasing spin rate of Explorer XII (about 0.1 percent per day) can be accounted for by solar radiation pressure on the paddles, which are pitched in a direction that would increase spin rate for the current sun angle (Reference 14).

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INDUCED ENVIRONMENTS

This discussion so far has considered those space environments which derive from natural causes. A scientific satellite experiences several induced environments, primarily during the launch phase, which must be considered. These include shock, vibration, noise, spin, dynamic balance, acceleration, and aerodynamic heating. The nature and extent of these environments have been discussed in the technical literature.

CONCLUDING REMARKS

The next decade, in which man will attempt the conquest of the Moon, will place a tremendous responsibility on the scientific and technological resources of this country. Artificial satellites have proved to be powerful research tools by which man can discover the origin, nature, and extent of the space environment. They also have had practical applications both in meteorology and communications. The scientific satellite will provide the basic knowledge for man to proceed confidently into space. It may provide the basis for great technological advances for the benefit of mankind in the ensuing years. The ultimate practical value of any exploration is difficult to assess in the beginning.

The President's Science Advisory Committee stated on March 26, 1958:

"Scientific research, of course, has never been amenable to rigorous cost accounting in advance. Nor, for that matter, has exploration of any sort. But if we have learned one lesson, it is that research and exploration have a remarkable way of paying off—quite apart from the fact that they demonstrate that man is alive and insatiably curious. And we all feel richer for knowing what explorers and scientists have learned about the universe in which we live."*

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The writer has had the opportunity of seeing the space program develop from its infancy. This paper was culled from this experience and by gleaning and summarizing appropriate material from the many references cited. The author gratefully acknowledges the very excellent work in these references, which he has freely used.

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<p>NASA TN D-1340 National Aeronautics and Space Administration. SCIENTIFIC SATELLITES AND THE SPACE ENVIRONMENT. John C. New. June 1962. 22p. OTS price, \$0.75. (NASA TECHNICAL NOTE D-1340)</p> <p>This paper outlines the need for space science information in the next 10 years and the general objectives of the NASA space programs. The scientific satellite is defined and contrasted to military and application satellites and a graphical summary of the satellites launched to date is presented. A typical space vehicle mission profile is also given. The general characteristics of the space environment, such as atmospheric structures, particles, and fields, are discussed. Major findings from satellites, such as the discovery of the Van Allen belts, the pear shape of the earth, and effects of solar radiation pressure, are briefly surveyed.</p>	<p>I. New, John C. II. NASA TN D-1340 (Initial NASA distribution: 7, Astrophysics; 21, Geophysics and geodesy; 30, Physics, atomic and molecular; 31, Physics, nuclear and particle; 33, Physics, theoretical.)</p>	<p>NASA</p>
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